



# FAT, commissioning, and training on all elements of the mobile storage/trailers



Deliverable 3.4

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## Document history and status

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## Preface

The aim of **GREEN HYSLAND** is to **deploy a Hydrogen ecosystem on the island of Mallorca**. The initiative is receiving **10 Million Euros of funding** from the European Commission through the **Clean Hydrogen Partnership**. It is a 5-year-project that started on the 1<sup>st</sup> January 2021, and will end on 31<sup>st</sup> December 2025. The consortium is formed by **30 partners from 11 countries**, 9 from the European Union, as well as Chile and Morocco. The project will deliver the **first hydrogen valley of the Mediterranean**, developing a fully functioning hydrogen (H<sub>2</sub>) ecosystem covering all the value chain, from the production to the distribution and consumption of, at least, 330 tonnes per year of green H<sub>2</sub>, traced through a Guarantee of Origin System. This hydrogen will be used in six different applications, as follows:

- The **H<sub>2</sub> pipeline and the injection point** of part of the H<sub>2</sub> produced at the Lloseta plant into the island's natural gas network operated by Redexis.
- The **100 kWe fuel cell** that will supply electricity to the maritime station of the **Balearic Port**.
- The **50 kWe CHP** system to be located in the **Iberostar Bahía de Palma hotel (4\*)**, which will cover part of the hotel's energy demand.
- The **25 kWe CHP** system to be located at the **Municipal Sports Centre in Lloseta**, which will cover part of the site's energy demand.
- The integration of **5 hydrogen buses to the EMT** city bus fleet of Palma de Mallorca.
- The integration of **H<sub>2</sub> vans** in the Alfill Logistics vehicle fleet as well as the search for rental car companies to incorporate H<sub>2</sub> vehicles in their **rental car fleets**.

The infrastructures which will be developed within the project are:

- The **green H<sub>2</sub> production plant** located on CEMEX land in Lloseta.
- The deployment of a **Hydrogen Refuelling Station (HRS)** at the EMT facilities.
- The development of tube trailers which will transport the H<sub>2</sub> produced in Lloseta's plant to the different applications.

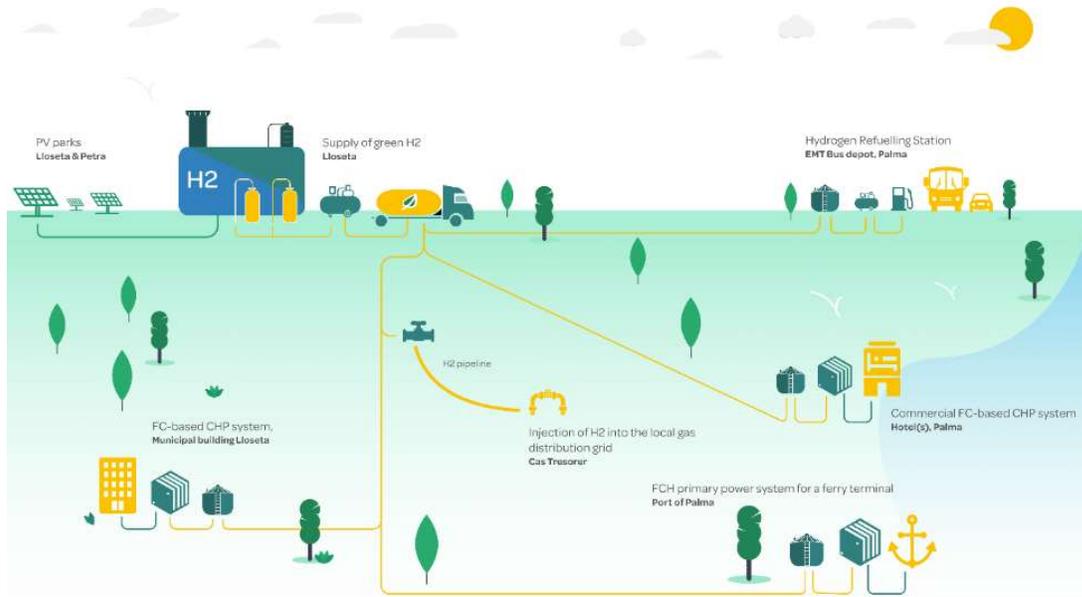
This initiative aims to reduce the CO<sub>2</sub> emissions of Mallorca up to 20,700 tonnes per year by the end of the project.

The project will also deliver a **roadmap towards 2050** that compiles a long-term vision for the **development of a widespread H<sub>2</sub> economy in Mallorca and the Balearic Region**, in line with the **environmental objectives set for 2050**. This long-term roadmap will be an evolution of the current regional roadmap for the deployment of renewable energies and the energy transition, and will involve local and regional stakeholders through public consultations.

In addition, GREEN HYSLAND contemplates the **development of replication experiences** in five other EU islands: Madeira (PT), Tenerife (ES), Aran (IE), Greek Islands and Ameland (NL) as well as Chile and Morocco. Within the project, the impact of deployment of H<sub>2</sub> technologies at regional level (Mallorca and Balearic islands) at technical, economic, energy, environmental, regulatory and socioeconomic levels will be analyzed. Additionally, detailed techno-economic studies for scaling-up renewable H<sub>2</sub>

production, interconnecting infrastructure and local H<sub>2</sub> end-uses, both within the island of Mallorca and beyond, will be developed to facilitate and de-risk future sector investment.

The infrastructures for the hydrogen production and distribution, together with the end-users' pilot sites and the logistics required for the green hydrogen distribution will be developed as follows:



No	Participant Name	Short Name	Country Code	Logo
1	ENAGÁS RENOVABLE S.L.	EGR	ES	
2	ACCIONA ENERGIA S.A.	ACCIONA ENER	ES	
3	REDEXIS GAS S.A.	REDEXIS GAS SA	ES	
4	Empresa Municipal de Transportes Urbans de Palma de Mallorca S.A.	EMT-PALMA	ES	
5	CALVERA HYDROGREN S.A	CALVERA	ES	
6	AJUNTAMENT DE LLOSETA	Lloseta Council	ES	

7	AUTORIDAD PORTUARIA DE BALEARES	PORTS BALEARS	ES	
8	CONSULTORIA TECNICA NAVAL VALENCIANA S.L.	COTENAVAL	ES	
9	BALEARIA EUROLINEAS MARITIMAS S.A.	BALEARIA	ES	
10	INSTITUTO BALEAR DE LA ENERGIA	IBE	ES	
11	UNIVERSITAT DE LES ILLES BALEARS	UIB	ES	
12	FUNDACION PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGIAS DEL HIDROGENO EN ARAGON	FHa	ES	
13	CENTRO NACIONAL DE EXPERIMENTACION DE TECNOLOGIAS DE HIDROGENO Y PILAS DE COMBUSTIBLE CONSORCIO	CNH2	ES	
14	ASOCIACION ESPANOLA DEL HIDROGENO	AeH2	ES	
15	COMMISSARIAT A L'ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES	CEA	FR	
16	ENERCY BV	ENER	NL	
17	HYENERGY TRANSSTORE BV	HTS	NL	
18	STICHTING NEW ENERGY COALITION	NEW ENER.COALIT	NL	
19	HYCOLOGNE GMBH	HyCologne	DE	
20	FEDERATION EUROPEENNE DES AGENCES ET DES REGIONS POUR L'ENERGIE ET L'ENVIRONNEMENT	FEDARENE	BE	

21	NATIONAL UNIVERSITY OF IRELAND GALWAY	NUI GALWAY	IE	
22	THE EUROPEAN MARINE ENERGY CENTRE LIMITED	EMEC	UK	
23	GASNAM - ASOCIACION IBERICA DE GASNATURAL Y RENOVABLE PARA LA MOVILIDAD	GASNAM	ES	
24	UNIVERSIDAD DE LA LAGUNA	ULL	ES	
25	ENERGY CO-OPERATIVES IRELAND LIMITED	En.Coop.Ireland	IE	
26	AGENCIA REGIONAL DA ENERGIA E AMBIENTE DA REGIAO AUTONOMA DA MADEIRA	AREAM	PT	
27	GEMEENTE AMELAND	Gem.Ameland	NL	
28	DIKTYO AEIFORIKON NISON TOY AIGAIUO AE	DAFNI	EL	
29	ASOCIACION CHILENA DE HIDROGENO	H2 CHILE	CL	
30	Association Marocaine pour l'Hydrogène et le Développement Durable	AHMYD	MA	
31	HYENERGY CONSULTANCY LTD	HYE	NL	
32	ENAGÁS S.A.	ENAGAS	ES	
33	Power to Green Hydrogen Mallorca S.L.	P2GH2M	ES	

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## 1. Executive Summary

Calvera Hydrogen is responsible for the design and manufacturing of hydrogen tube trailers, mobile storage modules, and associated auxiliary systems, including the hydrogen filling panel. These components are essential to the Green Hysland project, in which Calvera acts as a key partner providing the necessary equipment for the hydrogen supply chain.

This document aims to deliver comprehensive information regarding Factory Acceptance Testing (FAT), commissioning, and training for all elements provided by Calvera. The information enclosed will serve as a critical foundation for the implementation and operation of the supplied equipment, ensuring proper setup, functionality, and safety.

Additionally, this document is designed to support the scalability of Green Hysland, offering valuable insights and guidance for potential replication at other sites. Calvera's role in the project extends beyond the supply of equipment, encompassing the training and knowledge transfer necessary to empower future operators in effectively managing and maintaining hydrogen-based solutions.

## 2. Tube Trailer

### 2.1 Factory Acceptance Test (FAT)

The Factory Acceptance Test (FAT) for the tube trailers focuses on ensuring the equipment is tested under controlled conditions prior to being shipped and installed at the customer's site.

#### Key Sections of the FAT:

##### 1. Preliminary Considerations:

- The FAT process requires essential utilities such as compressed air and nitrogen, as well as necessary safety evaluations.
- Personal protective equipment (PPE) is mandatory for all operators and includes gloves, face shields, helmets, safety shoes, and hearing protection. The test area should be properly marked and delimited according to the specific risks involved in handling pressurized systems.

##### 2. Installation Inspection:

- Safety Inspection: Verify that the test area is properly delimited and marked according to the risks of the work to be performed.
- Ensure that operators are equipped with the necessary PPE for working with the mobile storage units.
- If the equipment is being tested with flammable gas, all materials in the defined explosive zones must be suitable for that environment.
- The vent system of the equipment must be connected to a facility vent that can handle the flow and pressure of the equipment being tested.
- Check that all necessary connections for pressurization and operation are available at the test site.

##### 3. Chassis and Non-Pressure Pre-Checks:

- Examination of the tube trailer chassis, including earthing points, anti-tow-away systems, and wheel conditions.
- Visual Inspection: Inspect the equipment for any sharp edges or surfaces that could pose a safety hazard.

- Verify that all valves are accessible and that they operate smoothly, reaching full open/close positions.
- Ensure that pressure gauges are set to 0 bar and are filled with dampening fluid to prevent erratic movement during testing.

#### 4. Filling and Leakage Tests:

- The system is pressurized using compressed nitrogen in increments, starting at 50 bar and gradually increasing to 100, 150, 200, 250, and 300 bar.
- Leak detection is performed at each stage using soap water or a similar method. If any leaks are detected, the equipment must be depressurized, repaired, and re-tested.
- At each pressure increment, ensure that the pressure gauges are reading correctly, and that the system maintains the specified pressure without any leakage.
- Manual valves are checked to ensure they operate smoothly and maintain tightness under pressure.
- Once the leak test is successfully completed at 300 bar, the system is depressurized to prepare for final inspections.

#### 5. Pre-Shipment Checks:

- Ensure that all components are present and clearly labelled according to the P&ID provided by Calvera or the customer.
- Confirm that the equipment is fitted with an approval plate in an accessible, clearly visible location.
- Warning signs and accessibility doors must be clearly visible and functional.

See Annex 1 as an example of a FAT document.

## 2.2 Commissioning. Site Acceptance Test (SAT)

The Site Acceptance Test (SAT) ensures that the tube trailers and associated systems are functioning correctly once installed at the project site. This procedure is critical to validate the system's performance under actual site conditions.

### Key Sections of the SAT:

#### 1. Preliminary Conditions:

- A pre-test meeting is conducted with responsible personnel to review the P&ID (Piping and Instrumentation Diagram) and the venting system.
- The test area must be properly delimited and marked according to the specific risks involved in working with pressurized hydrogen systems.
- Utilities such as compressed hydrogen, an earthing point, and suitable connections for hydrogen are required. Additionally, appropriate venting facilities must be available for the safe release of gas.
- Personal protective equipment (PPE) is mandatory for all operators, including gloves, face shields, helmets, safety shoes, and anti-spark tools.

#### 2. Installation Inspection:

- Safety Checks: Confirm that the area has been properly delimited and marked, and that the facility has pressure relief devices as per the applicable regulations for pressure equipment.
- The surface where the equipment is installed should be firm, flat, and clean to ensure safe operation.
- Operators and facility personnel must be informed of the tests in advance, and those present should have the necessary PPE.
- The area should be classified as suitable for operation in explosive environments.
- Hydrogen interface connections should be compatible with the tube trailer to ensure smooth operation.

#### 3. Equipment Status:

- A visual inspection is carried out to verify that the equipment is free from any external damage that may have occurred during transportation to the site.
- All components must be accounted for and clearly labelled according to the P&ID.

- Ensure that the equipment has a visible approval plate and that all warning signs are in place.
- Accessibility doors and hydrogen connectors should be functional and clean, with no obstructions.

#### 4. Non-Pressure Pre-Checks:

- Visual Inspection: Inspect the equipment for any sharp edges or surfaces that could pose a safety hazard.
- Verify that all valves are accessible and that they operate smoothly, reaching full open/close positions.
- Ensure that pressure gauges are set to 0 bar and are filled with dampening fluid to prevent erratic movement during testing.

#### 5. Hydrogen Purge Protocol:

- The system undergoes a controlled hydrogen purge to eliminate any residual gases and prepare for the filling process.

#### 6. Filling and Leakage Test:

- The equipment is filled with hydrogen in stages, starting at 50 bar and progressing through 100, 150, 200, 250, and 300 bar.
- Leak detection is performed at each stage, using either soap water or hydrogen detectors, with immediate repair procedures if any leaks are detected.

#### 7. Approval:

- Once all tests are completed and the equipment passes the necessary checks, both supplier and the client sign off to approve the SAT process.

See Annex 2 as an example of a SAT document

## 2.3 Training

The training for the operation and maintenance of the tube trailers focuses on ensuring that all personnel are properly trained to safely and effectively manage the system. This training covers several critical areas, including safety protocols, operation procedures, and maintenance routines.

### Key Areas of Training:

#### 1. Safety Protocols:

- Personnel must be familiar with the necessary safety precautions, including the use of personal protective equipment (PPE) such as anti-static clothing, gloves, and hearing protection.
- Proper grounding procedures must be understood to avoid static discharge when operating in explosive atmospheres (ATEX zones).
- Operators must be trained on how to handle emergencies, including the activation of emergency stop buttons and how to safely vent the system in case of a gas leak.

#### 2. Operational Procedures:

The operational procedures for the tube trailers involve detailed step-by-step instructions for safe and efficient handling of hydrogen storage and transfer. Proper training on these procedures ensures that operators can manage the system safely, avoid potential hazards, and maintain system integrity.

##### ➤ Installation and Setup:

- Before operating the tube trailers, it is essential to ensure they are installed correctly. The unit must be placed on a level, stable surface that can support the full weight of the trailer and its contents.
- The installation site should be an outdoor, well-ventilated area, or in the case of indoor installation, there must be adequate ventilation systems, including gas and flame detectors.
- Operators must ensure that the trailer is grounded to prevent static electricity buildup. This involves connecting the trailer to a reliable grounding system using the grounding points provided on the chassis.
- Before beginning any operation, the system should be visually inspected for any signs of physical damage, especially around connection points and valves.

➤ **Pre-Operational Checks:**

- Ensure that the tractor unit is disconnected from the trailer and moved a safe distance away.
- Block the trailer's wheels and engage the pneumatic brakes to secure the unit during operation.
- Perform a visual inspection of all valves, connectors, and hoses to verify that everything is intact and free of dirt, debris, or visible damage.
- Verify the cleanliness of the connection points and hoses to avoid contamination during filling or discharge processes. It is recommended that both ends of the connection (stationary equipment and tube trailer) are checked to ensure no dirt or moisture is transferred.

➤ **Filling Process:**

- The filling process involves transferring hydrogen into the tube trailer. It must be done carefully and in a controlled manner to prevent over-pressurization or leaks.
- The operator should:
  1. Connect the filling hose from the stationary hydrogen supply to the inlet quick connector on the tube trailer.
  2. Open the manual section valves to allow gas flow into each section of the storage.
  3. Slowly open the main inlet valve to start the filling process. It is critical to increase pressure in controlled increments:
    - Fill to 50 bar, pause for 5-10 minutes, and inspect all connection points for leaks using soap water.
    - Repeat this process, increasing to 100 bar, 150 bar, 200 bar, 250 bar, and finally 300 bar, while performing leak checks at each pressure stage.
  4. Throughout the process, the operator must closely monitor the pressure gauges to ensure that the system does not exceed the operating pressure of 300 bar.
- If any leaks are detected during the filling process, operations should be stopped immediately, the leak repaired, and the system should be re-pressurized to confirm that the leak has been resolved.

➤ **Discharge Process:**

- The discharge or dispensing of hydrogen is a controlled process to transfer hydrogen from the tube trailer to the downstream system.
- The steps for discharge include:

1. Connect the discharge hose to the outlet quick connector on the tube trailer.
2. Open the section valves to allow gas flow from each section of the storage.
3. Slowly open the main outlet valve and begin the discharge process, ensuring that pressure is controlled using the pressure gauges.
4. The operator should monitor the discharge rate and ensure that it remains within the safe operating range.
5. Once the discharge is complete, close all section and outlet valves, vent any remaining pressure in the hose, and then disconnect the hose.

➤ **First-Time Filling (Commissioning Process):**

- During the first-time filling, the procedure is slightly different to ensure the system is fully operational and leak-free. Operators are trained to:
  1. Fill the system one section at a time, with all section valves closed except for the section being filled.
  2. Fill in small increments, starting at 50 bar and checking for leaks, progressing in increments of 50 bar up to 300 bar.
  3. This method allows for the identification of potential leaks or issues in specific sections before the system is fully pressurized.

➤ **Inertization Process:**

- Inertization is the process of replacing the hydrogen gas with an inert gas, such as nitrogen, to safely maintain or transport the system when it is not in use.
- The process involves:
  1. Connecting a nitrogen supply to the system and filling the tube trailer to 15 bar.
  2. Venting the nitrogen to purge the system, then repeating the process two additional times to ensure all hydrogen has been flushed out.
  3. After the inertization, the system should be sealed, and the nitrogen pressure should remain slightly positive to avoid contamination or moisture entering the system.

**3. Maintenance Routines:**

- Daily Inspections: Operators must conduct visual inspections of the system to check for any signs of damage, deformation, or leaks in the structure and equipment.

- Preventive Maintenance: Training should cover periodic tasks such as checking the cylinder clamps, grounding system continuity, and ensuring all valves, pressure gauges, and threaded connections are functioning properly and free of leaks.
- System Preservation: If the tube trailer is not in use for extended periods, it must be inerted with nitrogen, and regular checks on the valve operations should be conducted to prevent system deterioration.

#### 4. Environmental and ATEX Compliance:

- Operators should be trained on the environmental protection measures, including minimizing material waste and recycling according to local regulations.
- Personnel must also be aware of the ATEX guidelines to avoid the creation of sparks or static discharges in potentially explosive atmospheres.

By completing this training, personnel will be equipped with the knowledge necessary to operate the tube trailers safely, maintain them efficiently, and respond appropriately to any emergency situations.

See Annex 3 as an example of a training plan.

## 3. Mobile Storage

### 3.1 Factory Acceptance Test (FAT)

The Factory Acceptance Test (FAT) for mobile storage units is a critical process that verifies the equipment's integrity and readiness for safe operation before it is shipped to the site. This document outlines the key steps and procedures involved in the FAT process to ensure the system meets operational and safety standards.

#### **Key Sections of the FAT:**

##### **1. Preliminary Considerations:**

- The FAT process requires essential utilities such as compressed nitrogen at working pressure and properly anchored hoses for pressurization.
- Personal protective equipment (PPE) is mandatory for all operators and includes gloves, face shields, helmets, safety shoes, and hearing protection. The test area should be properly marked and delimited according to the specific risks involved in handling pressurized systems.

##### **2. Installation Inspection:**

- Safety Inspection: Verify that the test area is properly delimited and marked according to the risks of the work to be performed.
- Ensure that operators are equipped with the necessary PPE for working with the mobile storage units.
- If the equipment is being tested with flammable gas, all materials in the defined explosive zones must be suitable for that environment.
- The vent system of the equipment must be connected to a facility vent that can handle the flow and pressure of the equipment being tested.
- Check that all necessary connections for pressurization and operation are available at the test site.

##### **3. Non-Pressure Pre-Checks:**

- Visual Inspection: Inspect the equipment for any sharp edges or surfaces that could pose a safety hazard.
- Verify that all valves are accessible and that they operate smoothly, reaching full open/close positions.

- Ensure that the pressure gauges are set to 0 bar and are filled with dampening fluid to prevent erratic movement during testing.

#### 4. Filling and Leakage Test:

- The system is pressurized using compressed nitrogen in increments, starting at 50 bar and gradually increasing to 100, 150, 200, 250, and 300 bar.
- Leak detection is performed at each stage using soap water or a similar method. If any leaks are detected, the equipment must be depressurized, repaired, and re-tested.
- At each pressure increment, ensure that the pressure gauges are reading correctly, and that the system maintains the specified pressure without any leakage.
- Manual valves are checked to ensure they operate smoothly and maintain tightness under pressure.
- Once the leak test is successfully completed at 300 bar, the system is depressurized to prepare for final inspections.

#### 5. Pre-Shipment Checks:

- Ensure that all components are present and clearly labelled according to the P&ID.
- Confirm that the equipment is fitted with an approval plate in an accessible, clearly visible location.
- Warning signs and accessibility doors must be clearly visible and functional.

See Annex 1 as an example of a FAT document.

## 3.2 Commissioning. Site Acceptance Test (SAT)

The Site Acceptance Test (SAT) for mobile storage units ensures that the equipment is functioning correctly after installation at the project site. This procedure is critical to validate the system's performance under actual site conditions.

### Key Sections of the SAT:

#### 1. Preliminary Conditions:

- The test area must be properly delimited and marked according to the specific risks involved in working with pressurized hydrogen systems.
- Utilities such as compressed hydrogen, an earthing point, and suitable connections for hydrogen are required. Additionally, appropriate venting facilities must be available for the safe release of gas.
- Personal protective equipment (PPE) is mandatory for all operators, including gloves, face shields, helmets, safety shoes, and anti-spark tools.

#### 2. Installation Inspection:

- Safety Checks: Confirm that the area has been properly delimited and marked, and that the facility has pressure relief devices as per the applicable regulations for pressure equipment.
- The surface where the equipment is installed should be firm, flat, and clean to ensure safe operation.
- Operators and facility personnel must be informed of the tests in advance, and those present should have the necessary PPE.
- The area should be classified as suitable for operation in explosive environments.
- Hydrogen interface connections should be compatible with the mobile storage unit to ensure smooth operation.

#### 3. Equipment Status:

- A visual inspection is carried out to verify that the equipment is free from any external damage that may have occurred during transportation to the site.
- All components must be accounted for and clearly labelled according to the P&ID.
- Ensure that the equipment has a visible approval plate and that all warning signs are in place.

- Accessibility doors and hydrogen connectors should be functional and clean, with no obstructions.

**4. Non-Pressure Pre-Checks:**

- Inspect the equipment for any sharp edges or surfaces that may pose a safety risk.
- Verify that all valves are accessible and that manual valves open and close smoothly.
- Pressure gauges should indicate 0 bar and must be filled with dampening fluid to ensure accurate readings.

**5. Hydrogen Purge Protocol:**

- The system undergoes a controlled hydrogen purge to eliminate any residual gases and prepare for the filling process.

**6. Filling Process at Working Pressure:**

- The equipment is filled with hydrogen in stages, starting at 50 bar and progressing through 100, 150, 200, 250, and 300 bar.
- Leak detection is performed at each stage, using either soap water or hydrogen detectors, with immediate repair procedures if any leaks are detected.

**7. Approval:**

- Once all tests are completed and the equipment passes the necessary checks, both supplier and the client sign off to approve the SAT process.

See Annex 2 as an example of a SAT document

### 3.3. Training

The training for the operation and maintenance of mobile storage units focuses on ensuring that personnel are fully equipped to handle these systems safely and efficiently. Proper training covers essential safety measures, operation procedures, and routine maintenance tasks.

#### Key Areas of Training:

##### 1. Safety Protocols:

- Personnel must follow the safety recommendations outlined in the manual, including the use of Personal Protective Equipment (PPE), such as gloves, safety shoes, and anti-noise headphones (compulsory during venting processes).
- Operators must understand the risks associated with working in ATEX environments (explosive atmospheres) and the need to avoid using non-approved equipment that could ignite explosive gases.
- Grounding procedures are critical to prevent static discharge, particularly when the system is operated in areas with a high risk of explosion. Proper earthing of the equipment ensures safety during hydrogen filling or dispensing.

##### 2. Operational Procedures:

- Installation: The mobile storages must be installed on a firm, flat surface and in a well-ventilated area. In cases where it is installed indoors, adequate ventilation systems should be in place.
- Pre-Operational Steps: Operators must inspect the cleanliness of the inlet/outlet connector before any connection is made. If anomalies are detected, the person in charge should be notified before continuing with operations.
- First Filling Process: During the first fill, the unit undergoes a multi-stage pressurization process using hydrogen:
  1. Fill the mobile storage up to 15 bar and vent it. Repeat this process three times.
  2. Gradually fill the unit to 50, 100, 150, 200, 250, and 300 bar, checking for leaks at each pressure stage using soapy water.
- Filling Process: Subsequent fillings should follow similar steps, with the pressure gauges being monitored continuously. Operators must ensure that all valves are opened and closed gradually to avoid sudden pressure changes.
- Dispensing Process: Operators should connect the mobile storage to the external installation, and the pressure gauge must be monitored closely during the dispensing process. Gradual opening of valves is essential to maintain safety.

### 3. Maintenance Routines:

- Daily Inspections: Operators must carry out visual inspections of the structure and system components, paying attention to signs of damage, such as deformations or paint defects.
- Preventive Maintenance: Regular checks should be conducted on critical components such as the manifold, valves, and threaded connections. Tightness of threaded connections should be verified using soapy water under pressure. All maintenance activities must be recorded in a checklist to ensure compliance and preserve the equipment's warranty.
- Inertization Process: If the PED storage block spends a prolonged time disconnected from the installation and without use, it must remain inertized and with all valves closed.

### 4. Environmental and ATEX Compliance:

- Operators must be trained on minimizing material waste and recycling according to local environmental regulations. Additionally, they must understand the guidelines for operating in ATEX environments, ensuring that no unauthorized equipment is used near the system.

By completing this training, personnel will be equipped with the necessary skills to safely operate the mobile storage units, carry out regular maintenance, and handle any potential emergencies.

See Annex 3 as an example of a training plan.

## 4. Hydrogen Filling Panel

### 4.1 Factory Acceptance Test (FAT)

The Factory Acceptance Test (FAT) for the Hydrogen Filling Panel ensures that the equipment is tested in a controlled environment to verify its functionality, safety, and readiness for operation before being shipped to the project site.

#### Key Sections of the FAT:

##### 1. Preliminary Considerations:

- The FAT process requires essential utilities such as compressed air, compressed nitrogen and a 24 VDC power supply for equipment operation.
- Personal protective equipment (PPE) is mandatory for all operators and includes gloves, face shields, helmets, safety shoes, and hearing protection. The test area should be properly marked and delimited according to the specific risks involved in handling pressurized systems.

##### 2. Installation Inspection:

- Safety Inspection: Verify that the test area is properly delimited and marked according to the risks of the work to be performed.
- Ensure that operators are equipped with the necessary PPE for working with the mobile storage units.
- If the equipment is being tested with flammable gas, all materials in the defined explosive zones must be suitable for that environment.
- The vent system of the equipment must be connected to a facility vent that can handle the flow and pressure of the equipment being tested.
- Check that all necessary connections for pressurization and operation are available at the test site.

##### 3. Non-Pressure Pre-Checks:

- Visual Inspection: The equipment should be free from any sharp edges or surfaces that could pose a hazard.
- Ensure that all valves are accessible and operate smoothly, reaching full open/close positions.
- Check and record the tare and serial numbers of the safety relief valves.

- Pressure Gauges should indicate a pressure of 0 bar and be filled with dampening fluid to ensure stable readings. Additionally, check valves and filters must be correctly positioned in relation to the flow direction.

#### 4. Electrical Pre-Checks:

- Ensure that the control cabinet is properly positioned, anchored, and wired.
- Check that all cables are labelled according to the wiring diagrams and verify electrical continuity between metal parts and instrumentation.
- Test the functionality of the HMI interface and verify that pilot-operated valves work correctly when controlled from the HMI.
- Verify the configuration and correct signals for pressure transmitters and temperature transmitters as well as the operation of limit switches for pneumatic actuators.

#### 5. Filling and Leakage Test:

- The system is pressurized using compressed nitrogen in increments, starting at 50 bar and gradually increasing to 100, 150, 200, 250, and 300 bar.
- Leak detection is performed at each stage using soap water or a similar method. If any leaks are detected, the equipment must be depressurized, repaired, and re-tested.
- At each pressure increment, ensure that the manometers are reading correctly, and that the system maintains the specified pressure without any leakage.
- Manual valves are checked to ensure they operate smoothly and maintain tightness under pressure.
- Once the leak test is successfully completed at 300 bar, the system is depressurized to prepare for final inspections.

See Annex 1 as an example of a FAT document.

## 4.2 Commissioning. Site Acceptance Test (SAT)

The Site Acceptance Test (SAT) for the Hydrogen Filling Panel ensures that the equipment is installed and operating correctly at the project site. This procedure is critical to validate the system's performance under actual site conditions.

### Key Sections of the SAT:

#### 1. Preliminary Considerations:

- Utilities required for the SAT include compressed hydrogen to reach the specified working pressure of 300 bar.
- Personal protective equipment (PPE), such as gloves, face shields, helmets, safety shoes, and anti-static clothing, must be worn by all operators.
- Reference documentation, such as the P&ID, wiring diagrams, and general arrangement drawings, should be available for consultation during the SAT.

#### 2. Installation Inspection:

- Safety Checks: Confirm that the area has been properly delimited and marked, and that the facility has pressure relief devices as per the applicable regulations for pressure equipment.
- The surface where the equipment is installed should be firm, flat, and clean to ensure safe operation.
- Operators and facility personnel must be informed of the tests in advance, and those present should have the necessary PPE.
- The area should be classified as suitable for operation in explosive environments.
- Hydrogen interface connections should be compatible with the Hydrogen Filling Unit to ensure smooth operation.

#### 3. Non-Pressure Pre-Checks:

- Visual Inspection: Inspect the equipment to ensure it is free from any damage sustained during transportation or installation.
- Ensure that the approval plate is installed in a visible and accessible location.
- Verify that warning signals are clearly visible, and that access doors operate properly.
- Inspect the hydrogen and air hoses to ensure they are free from damage, and that connectors are clean and free of dust or moisture.

**4. Electrical Pre-Checks:**

- Ensure that the equipment is properly connected to the general grounding system.
- Verify electrical continuity between the control cabinet terminals and the Hydrogen Filling Panel.
- Test the communication between the control cabinet and the main control room.
- Verify that the HMI interface is functioning correctly, and that pneumatic valves reach open/close positions when operated manually.
- Check that all instrumentation signals (pressure and temperature transmitters) are correctly received by the control cabinet.

**5. Hydrogen Purge Protocol:**

- The system undergoes a controlled hydrogen purge to eliminate any residual gases and prepare for the filling process.

**6. Filling Process at Working Pressure:**

- The equipment is filled with hydrogen in stages, starting at 50 bar and progressing through 100, 150, 200, 250, and 300 bar.
- Leak detection is performed at each stage, using either soap water or hydrogen detectors, with immediate repair procedures if any leaks are detected.

**7. Approval:**

- Once all tests are completed and the equipment passes the necessary checks, both supplier and the client sign off to approve the SAT process.

See Annex 2 as an example of a SAT document

## 4.3 Training

The training for the operation and maintenance of the Hydrogen Filling Panel is crucial to ensure that personnel understand the correct procedures for safe and efficient handling of the system. Proper training covers essential safety guidelines, operational steps, and routine maintenance activities.

### Key Areas of Training:

#### 1. Safety Protocols:

- All operators must use Personal Protective Equipment (PPE), including gloves, safety shoes, hearing protection during venting, and anti-static clothing.
- Operators must be trained to handle the equipment within ATEX environments, ensuring that all electrical and mechanical tools are ATEX certified and suitable for explosive atmospheres.
- Grounding procedures: Proper earthing of the system is critical to prevent static discharges that could ignite hydrogen gas.

#### 2. Operational Procedures:

- Installation: The Hydrogen Filling Panel must be installed on a flat, firm surface, preferably outdoors or in a well-ventilated area indoors. Ensure the system is correctly grounded and connected to the required utilities.
- First Start-Up: The first use of the system involves purging the process line with hydrogen and filling it in stages to ensure no leaks. The steps include:
  1. Purge the system with hydrogen at 15 bar, then vent.
  2. Gradually fill the system to 50 bar, then 100, 200 and finally 300 bar, checking for leaks at each stage.
  3. If leaks are detected, stop operations, repair, and repeat the process.
- HMI Interaction: The operation of the Hydrogen Filling Panel is controlled through the HMI screen, which provides real-time information about the status of the process. The HMI also alerts the operator to any warnings or alarms during operation.
  1. It is essential that all personnel handling the equipment receive training on the proper use of the HMI screen. They should be informed about how to interpret the various notifications and understand the appropriate actions required.
  2. Operators must refer to the user manual of the equipment for detailed guidance on using the HMI and for a comprehensive explanation of all alerts and alarms that may occur during the operation. This ensures that any issues or warnings are handled correctly and safely.

### 3. Maintenance Routines:

- Daily Inspections: Operators must perform visual checks to ensure that no damage or deformation has occurred on the structure or valves. Inspections include checking the hoses for cleanliness and ensuring there are no leaks in the hydrogen and pneumatic lines.
- Preventive Maintenance: Regular checks should be carried out on critical components like valves, gauges, and filters to ensure they function correctly. Pressure gauges must be compared with transmitter readings to ensure accuracy, and filters should be cleaned or replaced regularly.
- Inertization Process: If a filling bay spends a prolonged time disconnected from the installation and without use, it must remain inertized and all valves closed.

### 4. Emergency Procedures:

- Operators must be familiar with the emergency stop procedures. If a gas leak is detected, the system must be immediately depressurized, and the power supply disconnected.
- Regular drills and training on how to respond to alarms and malfunctions are essential to ensure quick and efficient responses in case of emergencies.

By completing this training, personnel will be fully prepared to operate the Hydrogen Filling Panel safely, perform necessary maintenance, and respond effectively to any emergency situations that may arise.

See Annex 3 as an example of a training plan.

## 5. ANNEX 1 – FAT DOCUMENT

# FACTORY ACCEPTANCE TESTS (FAT)

## CONT30-T2-143 IDI22001-GH

				Cover Page	
				N. of Sheets: 4	Sheet No.: 1 of 4
Date	Elaborated	Date	Approved		Rev.1

<b>A. Equipment data</b>		
Reference	Customer	Project
Serial number	Order No.	Gas
Working Pressure	Design Pressure	Test pressure

<b>B. Preliminary considerations</b>
<p>Utilities:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Compressed air between 6 and 10 bar.</li> <li><input type="checkbox"/> Adequate site for tube trailer venting (safety evaluation executed by end user).</li> <li><input type="checkbox"/> Compressed N2 to a pressure of up to working pressure (see A. Equipment Data).</li> <li><input type="checkbox"/> Multi-pole truck connector with 24 VDC for auxiliary equipment supply.</li> <li><input type="checkbox"/> Hoses with anchor tow.</li> </ul> <p>Personal protective equipment required:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Gloves.</li> <li><input type="checkbox"/> Wrap-around face shield.</li> <li><input type="checkbox"/> Helmet.</li> <li><input type="checkbox"/> Safety shoes.</li> <li><input type="checkbox"/> Hearing protection.</li> <li><input type="checkbox"/> Hoses with anchor line.</li> </ul>

Pos.	Tasks	Visual	Doc.	OK	Remarks
<b>C. Inspection of the installation.</b>					
C1	The area has been correctly delimited and marked, according to the risk of the work to be performed.				
C2	The operators present at the test have the necessary personal protective equipment for working with pressure equipment.				
C3	In case of testing with flammable gas, check that all material under the defined explosive areas is suitable for operation in that area.				
C4	If applicable, the equipment vent has been connected to a facility vent suitable for the flow rate and vent pressure of the equipment.				
C5	The test facility has the necessary connections to pressurize and operate the equipment.				
C6	If it is necessary to work at heights, suitable harnesses and anchoring devices are available.				
C7	If necessary, presence of preventive recourse.				
Operator:		Quality Manager:			
Date: _____ Signature: _____		Date: _____ Signature: _____			
<b>E. Chassis checks.</b>					
E1	Earthing point is clean and free on paint.				
E2	Earthing wire and terminals are in good condition.				
E3	The anti-tow-away system maintains the truck brakes actuated while hydrogen connection ready to be plugged (lift 90° the anti-tow away).				

E4	Wheel chocks are provided with the chassis.				
E5	Wheel torque indicators are properly installed in the tires.				
E6	Fire extinguishers provided with the chassis.				
E7	Chassis lightning operates properly.				
E8	Visibility strips on the rear door are visible and intact.				
E9	Wheels remains pressurized.				
E10	Pneumatic chassis system does not leak (audible check).				
E11	Electrical connectors provide power from the truck and allow signal communication for stop, reverse and flashing lights.				
Operator:		Quality Manager:			
Date: _____ Signature: _____		Date: _____ Signature: _____			
<b>F. Non-pressure pre-checks.</b>					
F1	The equipment has no sharp edges or sharp surfaces.				
F2	All valves are accessible and allow proper handling.				
F3	Manual valves operate smoothly and reach close/open position.				
F4	Pressure gauges indicate a pressure of 0 bar.				
F5	Pressure gauges are filled with dampening fluid and have not lost the content.				
F6	Air-operated valves reach close/open position (visual indicator 0° and 90° position change from closed to open position in the actuator). For this purpose, connect the valves to the plant air supply system, or use the pneumatic portable control box.				
F7	The pneumatic push buttons isolate the air supply maintaining the ball valves closed when actuated. Compressed air supply required.				Air supply pressure range: 6 – 10 bar.
Operator:		Quality Manager:			
Date: _____ Signature: _____		Date: _____ Signature: _____			
<b>G. Filling &amp; leakage test.</b>					
G1	Connect the hydrogen hose to the main connector and, if applicable, connect the vent hose of the system.				
G2	Close the vent valves (needle and ball valves) then open the process vales of the tube trailer (both manual and air-operated ones).				Use pneumatic portable control box.
G3	Lift 90° the anti-tow away to allow main hydrogen connection coupling connection.				
G4	Supply Nitrogen until reaching 50 bar, displayed on all the pressure gauges. *				<input type="checkbox"/> Time: <input type="checkbox"/> Pressure: <input type="checkbox"/> Leakage test inspected by NOBO ok:
G5	Supply Nitrogen until reaching 100 bar, displayed on all the pressure gauges. *				<input type="checkbox"/> Time: <input type="checkbox"/> Pressure: <input type="checkbox"/> Leakage test inspected by NOBO ok:
G6	Supply Nitrogen until reaching 150 bar, displayed on all the pressure gauges. *				<input type="checkbox"/> Time: <input type="checkbox"/> Pressure: <input type="checkbox"/> Leakage test inspected by NOBO ok:
G7	Supply Nitrogen until reaching 200 bar, displayed on all the pressure gauges. *				<input type="checkbox"/> Time: <input type="checkbox"/> Pressure: <input type="checkbox"/> Leakage test inspected by NOBO ok:
G8	Supply Nitrogen until reaching 250 bar, displayed on all the pressure gauges. *				<input type="checkbox"/> Time: <input type="checkbox"/> Pressure: <input type="checkbox"/> Leakage test inspected by NOBO ok:
G9					<input type="checkbox"/> Time: <input type="checkbox"/> Pressure:

	Supply Nitrogen until reaching 300 bar, displayed on all the pressure gauges. *				<input type="checkbox"/> Leakage test inspected by NOBO ok:
G10	Verification of correct reading of pressure gauges.				<input type="checkbox"/>
G11	Checking the maneuvering and tightness of manual valves.				<input type="checkbox"/>
G12	Emptying the equipment.				<input type="checkbox"/>
G13	Road Test (Structure integrity verification)				Structure + chassis connected to a tractor to perform road test in the facilities surroundings.

\*If a leakage is detected in any step of the leakage test, the tube trailer must be emptied, prior repairing the leakage. Once the leakage has been repaired start with *G. Tube trailer leakage test*.

Operator:

Quality Manager:

Date:

Signature:

Date:

Signature:

### H. Pre-shipment checks.

H1	The equipment and its components are free from external damage before transportation at site.				
H2	The equipment includes all the components.				
H3	All elements are clearly identified, according to the P&ID provided by Calvera or by the customer.				
H4	The equipment has an approval plate in an accessible and clearly visible place.				
H5	Legal, maintenance and operating documentation is available at site.				
H6	Warning signs are clearly visible.				
H7	Accessibility doors open and close properly.				
H8	The equipment has the commercial labeling of CALVERA and/or the one provided by the customer.				
H9	The equipment is correctly packed and with the necessary protections for transport.				

Operator:

Quality Manager:

Date:

Signature:

Date:

Signature:

## 6. ANNEX 2 – SAT DOCUMENT

**SITE ACCEPTANCE TESTS (SAT)  
CONT30-T2-143 IDI22001-GH**

				Cover Page	
Date	Elaborated	Date	Approved	N. of Sheets: 4	Sheet No.: 1 of 4 Rev.0

<b>A. Equipment data</b>		
Reference	Customer	Project
Serial number	Order No.	Gas
Working Pressure	Design Pressure	Test pressure

<b>B. Preliminary considerations</b>
<ul style="list-style-type: none"> <li><input type="checkbox"/> Preliminary meeting with the personnel responsible for the test.</li> </ul> <p>Utilities:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Compressed air between 6 and 10 bar.</li> <li><input type="checkbox"/> Adequate site for tube trailer venting (safety evaluation executed by end user).</li> <li><input type="checkbox"/> Compressed H2 to a pressure of up to working pressure (see A. Equipment Data).</li> <li><input type="checkbox"/> Earthing point.</li> </ul> <p>Personal protective equipment required:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Gloves.</li> <li><input type="checkbox"/> Wrap-around face shield.</li> <li><input type="checkbox"/> Helmet.</li> <li><input type="checkbox"/> Safety and dissipative shoes.</li> <li><input type="checkbox"/> Anti-static clothing.</li> <li><input type="checkbox"/> Hearing protection.</li> <li><input type="checkbox"/> Anti-spark wrenches.</li> <li><input type="checkbox"/> Hoses with anchor line.</li> </ul>

Pos.	Tasks	Visual	Doc.	OK	Remarks
<b>C. Inspection of the installation.</b>					
C1	The area has been correctly delimited and marked, according to the risk of the work to be performed.				
C2	The facility has the required pressure relief devices in accordance with applicable pressure equipment regulations.				
C3	The surface where the equipment is located is clean, firm and flat.				
C4	The workers at the facility have been informed of the tests in advance.				
C5	The operators present at the test have the necessary personal protective equipment for working with pressure equipment.				
C6	In case of testing with flammable gas, the area is suitable, according to the explosive areas provided by Calvera for that equipment.				
C7	The installation has a grounding point in accordance with IEC Standard 60364, Section 54.				
C8	If applicable, the equipment vent has been connected to a facility vent suitable for the flow rate and vent pressure of the equipment.				
C10	Interface connections for hydrogen and compressed air are compatible with tube trailer connections.				
C11	Hydrogen and compressed air hoses are available at site and reach the tube trailer while parked without touching the ground while connected to the tube trailer.				
C12	Hydrogen and compressed hoses are in good condition and do not present any damage on the surface.				
C13	If necessary, presence of preventive resource.				

<b>D. Equipment status.</b>					
D1	The tube trailer and its components are free from external damage after transportation at site.				
D2	The tube trailer includes all the components.				
D3	All elements are clearly identified, according to the P&ID provided by the customer.				
D4	The equipment has an approval plate in an accessible and clearly visible place.				
D5	Legal, maintenance and operating documentation is available at site.				
D6	Warning signs are clearly visible.				
D7	Accessibility doors open and close properly.				
D8	Hydrogen and air connectors are not obstructed and are clean.				
<b>E. Non-pressure pre-checks.</b>					
F1	The equipment has no sharp edges or sharp surfaces.				
F2	All valves are accessible and allow proper handling.				
F3	Manual valves operate smoothly and reach close/open position.				
F4	Pressure gauges indicate a pressure of 0 bar.				
F5	Pressure gauges are filled with dampening fluid and have not lost the content.				
F6	Air-operated valves reach close/open position (visual indicator 0° and 90° position change from closed to open position in the actuator). For this purpose, connect the valves to the plant air supply system, or use the pneumatic portable control box.				
F7	The pneumatic push buttons isolate the air supply maintaining the ball valves closed when actuated. Compressed air supply required.				
<b>F. Tube trailer purge with H<sub>2</sub> protocol.</b>					
G1	Connect the hydrogen hose to the main connector and, if applicable, connect the vent hose of the system.				
G2	Close the vent valves (needle and ball valves) then open the process vales of the tube trailer (both manual and air-operated ones).				
G3	First fill. Supply hydrogen until reaching 15 bar, displayed on all the pressure gauges.				<input type="checkbox"/> Time: <input type="checkbox"/> Pressure: <input type="checkbox"/> Leakage test ok:
G4	Vent up to 0.5 bar (positive pressure inside).				
G5	Second fill. Supply hydrogen until reaching 15 bar, displayed on all the pressure gauges.				<input type="checkbox"/> Time: <input type="checkbox"/> Pressure: <input type="checkbox"/> Leakage test ok:
G6	Vent up to 0.5 bar (positive pressure inside).				
G7	Third fill. Supply hydrogen until reaching 15 bar, displayed on all the pressure gauges.				<input type="checkbox"/> Time: <input type="checkbox"/> Pressure: <input type="checkbox"/> Leakage test ok:
G8	Vent up to 0.5 bar (positive pressure inside).				
<b>G. Filling the tube trailer at working pressure protocol.</b>					
H1	Fill up to 50 bar and check for leaks*.				<input type="checkbox"/> Time: <input type="checkbox"/> Pressure: <input type="checkbox"/> Leakage test ok:
H2	Fill up to 100 bar and check for leaks*.				<input type="checkbox"/> Time: <input type="checkbox"/> Pressure: <input type="checkbox"/> Leakage test ok:
H3	Fill up to 150 bar and check for leaks*.				<input type="checkbox"/> Time: <input type="checkbox"/> Pressure: <input type="checkbox"/> Leakage test ok:



H4	Fill up to 200 bar and check for leaks*.				<input type="checkbox"/> Time: <input type="checkbox"/> Pressure: <input type="checkbox"/> Leakage test ok:
H5	Fill up to 250 bar and check for leaks*.				<input type="checkbox"/> Time: <input type="checkbox"/> Pressure: <input type="checkbox"/> Leakage test ok:
H6	Fill up to 300 bar and check for leaks*.				<input type="checkbox"/> Time: <input type="checkbox"/> Pressure: <input type="checkbox"/> Leakage test ok:
<p>If a leakage is detected in any of the hydrogen filling protocol, the affected section of the tube trailer must be emptied, prior repairing the leakage. Once the leakage has been repaired start with <i>H. Filling the tube trailer at Working pressure protocol.</i></p>					
CALVERA  Date:			Customer representative  Name and position:		
Technician:					

## 7. ANNEX 3 – TRAINING PLAN

## ***TRAINING PLAN FOR THE UNLOADING PANEL OF THE TUBE TRAILER***

This document outlines the training plan for operators to perform the unloading of hydrogen in a Tube Trailer using an Unloading Panel, as well as the necessary requirements to successfully complete the course.

### **Course Components**

The course will consist of the following sections:

- Identification of the components and parts of the panel.
- Utilization of the panel for unloading:
  - Functionality and components.
  - Process variables involved.
  - User interaction.
  - Execution of an unloading process.
- Incidents, potential faults, and troubleshooting.
- HMI interaction.

### **Materials Provided**

- **User Manual** for the unloading panel.
- **P&ID Diagram** for system parts identification.

### **Requirements**

To adequately complete the course, the following requirements must be strictly met:

- Availability of operators for a full session (4 hours).
- A fully operational hydrogen refueling station with all SAT tests successfully completed.
- Access to the control room.

**Necessary Supplies:**

- Compressed air between 6 and 10 bar.
- Electrical power supply: 220 VAC to the control panel.
- Electrical connection between the terminals of the unloading panel and the control room.
- Functional communication with the master control panel.

**During the Unloading Process of the Tube Trailer:**

- A **fully loaded Tube Trailer** will be required for unloading.

**Personal Protective Equipment (PPE) Required:**

- Gloves.
- Enclosed face shield or protective goggles.
- Helmet.
- Safety shoes.
- Anti-static clothing.
- Hearing protection.

*Note: The completion of the unloading processes for the Tube Trailer will depend on the client's facilities. The processes may be interrupted to avoid the need for fully unloading the tube trailer. Training may vary based on plant-specific requirements.*

**ATTENDANCE RECORD**

Name	Company	Date	Signature



# GREEN HYSLAND

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